23 June 2018

Time Allowed: 3 Hours

ELECTRICIAN'S THEORY EXAMINATION

Check the label on the back of this paper to ensure you have your paper.

INSTRUCTIONS – READ CAREFULLY

You have 10 minutes to read this paper but do not start writing until you are told to do so by the supervisor.

Answer all questions.

The pass mark for this examination is 60 marks.

Use a pen for written answers. **Do not** use a pencil or a red pen.

Drawing instruments and pencils may be used when diagrams are required. Marks are allocated on the basis of correctness.

Do not use correcting fluid or correcting tape.

Candidates are not permitted to use any Act, Regulation, Standard, Code of Practice, Handbook or other reference text in this examination.

PLEASE HAND THIS PAPER TO THE SUPERVISOR BEFORE LEAVING THE ROOM.

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assessment specialists

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Section 1

Question 1 **2 marks**

In New Zealand, the standard distribution system has the neutral conductor connected to the earth at the main switchboard on all low voltage installations. What name is given to this type of system?

Question 2 **2 marks**

State the test voltage used for carrying out an insulation resistance test on three-phase, 400V, electrical equipment incorporating MIMS elements.

Question 3 **2 marks**

State **one** reason why the resistance of the protective earthing conductor of a flexible cord for a Class I electrical appliance is set at a maximum of 1 Ω.

Question 4 **2 marks**

State **one** factor that determines the voltage drop in a 400V, final subcircuit TPS cable.

(turn over)

Question 5 **2 marks**

An isolator for 230V electrical equipment has been replaced. During the work the **phase (active) and neutral** were accidentally transposed at the **supply side** of the isolating switch.

What potential danger would this transposition create?

Question 6 **2 marks**

A voltage test for isolation is being carried out on a three-phase, 400V oven that may or may not be live.

State the main safety issue that would occur if the only testing done was between each phase.

Question 7 **2 marks**

List **two** types of earth electrode that may be used to connect an MEN system to the mass of earth.

1.

2.

Question 8 **2 marks**

State what is meant by the term **current rating** as it applies to an HRC fuse?

Question 9 **2 marks**

State **one** reason why an RCD tester is used to test a **PRCD**.

Question 10 **2 marks**

A three-phase induction motor is controlled by a star/delta starter that incorporates thermal overloads.

State **one** reason why HRC fuses are installed at the origin of the final subcircuit supplying the induction motor.

(turn over)

Section 2

Question 11 **2 marks**

Define the term **isolation** as it relates to three-phase equipment.

Question 12 **3 marks**

Describe how the **prove-test-prove** method of testing is carried out.

Question 13 **5 marks**

Danger tags and out-of-service tags are designed to promote safety in the workplace.

(a) Give a brief description of circumstances when a Danger Tag is used.

(b) Give a brief description of circumstances when an Out-of-Service Tag is used.

(c) State **two** precautions to be taken when attaching a danger tag to an isolating switch.

1.

2.

(turn over)

Section 3

Introduction

A nameplate of a three-phase, 4-pole, induction motor has the following information:

Frequency	**50 Hz**
Line voltage	400V
Line current	
kW	10
Efficiency	81.5%
Slip	4%

The line current lags the voltage by a phase angle of 35^0

Use the information in the introduction to answer questions 14, 15, 16 and 17.

Question 14

1 mark

Calculate the **power factor** of the motor.

Question 15

2 marks

Calculate the **input power** of the motor.

Question 16 **2 marks**

Calculate the **line current** of the motor.

Question 17 **5 marks**

(a) Calculate the **slip speed** of the motor.

(b) Calculate the **rotor speed** of the motor.

(turn over)

Section 4

Question 18 **4 marks**

Draw and label a circuit diagram of a 230V single-phase capacitor-start, capacitor-run induction motor.

Question 19 **2 marks**

State the main reason why a single-phase capacitor-start, capacitor-run induction motor would be used to drive a large air-conditioning fan, instead of a split-phase motor of the same rating.

Question 20 **2 marks**

State how a thermistor protects a three-phase induction motor when a mechanical overload occurs.

Question 21 **2 marks**

(a) What do the initials **BJT** mean when applied to semiconductors?

(b) What is a **transducer**?

(turn over)

Section 5

Figure 1 shows an earth-fault loop impedance tester plugged into a 230V socket outlet in an electrical installation. The socket outlet is protected by a 20A HRC fuse.

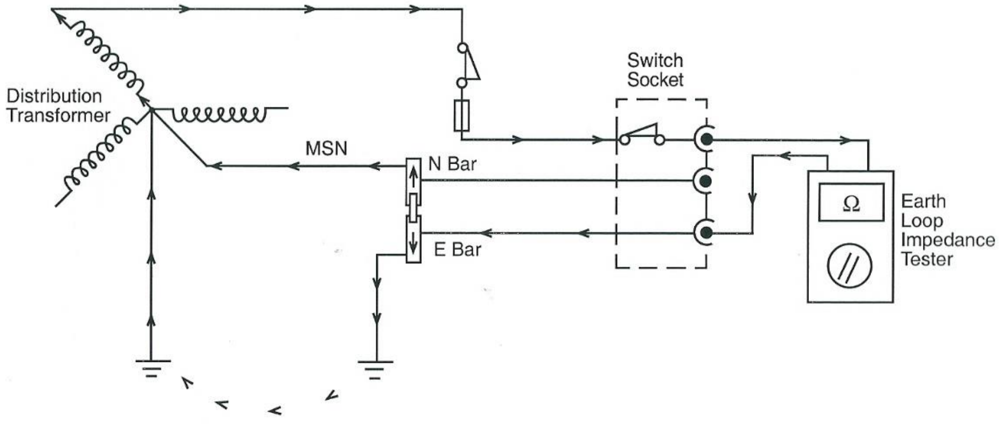


Figure 1

Question 22 **4 marks**

(a) State the reason why the earth-fault loop impedance test is carried out at the socket outlet.

(b) State the reason why an earth-fault loop impedance test is **also** carried out at the switchboard of the electrical installation in Figure 1.

Question 23 **2 marks**

You have carried out an earth fault loop impedance test on a domestic installation and the test indicates that the fault level is 1.2 kA. On the switchboard there are three rewireable fuses.

(a) The rewireable fuses must be replaced with MCBs. State **one** reason why the rewireable fuses need replacing.

(b) The rewireable fuses must be replaced with MCBs. State **one** reason why MCBs are used to replace the rewireable fuses.

Question 24 **2 marks**

Introduction

A three-phase, 400V workshop has been completely rewired. The work included all final subcircuits including a fixed wired, single-phase 2 kW water heater with a MIMS element. There was no change to the main earth system or main switchboard.

The required testing has been completed and the installation has been relivened. An earth-fault loop impedance test has been carried out on the main switchboard.

(a) What other earth fault loop impedance test needs to be carried out?

(b) State **one** reason why the earth fault loop impedance test stated in (24)(a) is carried out.

(turn over)

Question 25 **2 marks**

Most electrical installations are supplied from an MEN system of supply.

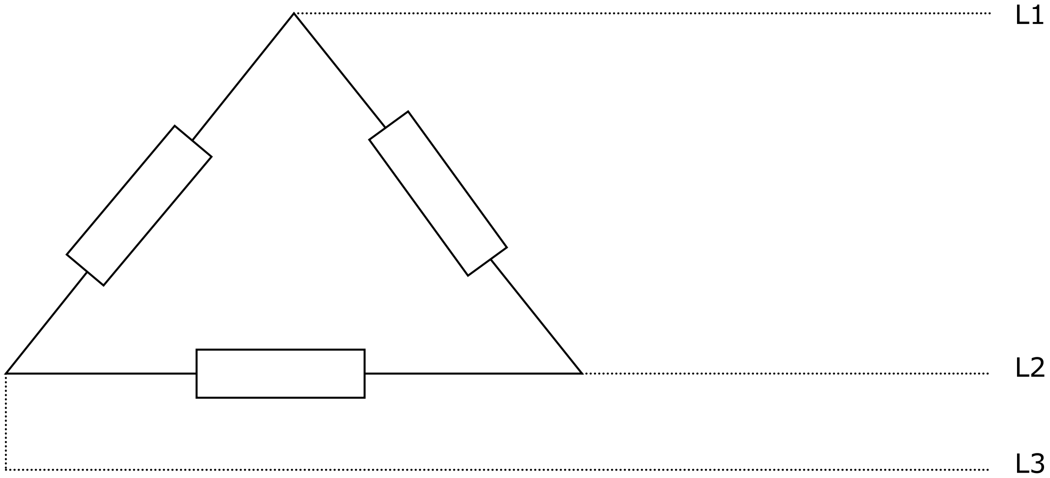
The earth fault loop is an integral part of an MEN system of supply to an electrical installation.

State **one** reason why the earth fault loop through the main neutral conductor to the star point of the distribution transformer is **more important** than the earth fault loop through the main earth and mass of earth to the star point of the distribution transformer.

Section 6

Introduction

The following diagram represents the three elements in a 400V, three-phase industrial kiln. Each element has a resistance of 17.77Ω.



Note: Voltage drop has no effect on the size of the cable because the route length is too short.

Use the information in the introduction to answer the following questions 26, 27, 28 and 29.

(turn over)

Question 26 **4 marks**

Use calculations to determine the minimum size three-phase copper cable that can carry the kiln load current when the elements are in the delta configuration.

- The cable will be installed unenclosed (touching).
- The ambient air temperature is 30^0C.
- The conductor temperature is 75^0C.

Refer to the tables on pages 18 and 19.

Question 27 **2 marks**

Calculate total **power** output of the kiln when the elements are in the delta configuration.

Question 28 **1 mark**

State the minimum current rating of the HRC fuses used to protect the final subcircuit supplying the kiln when the elements are in the delta configuration.

Question 29 **3 marks**

Calculate the **difference** in the power output of the kiln if the elements were connected in star.

(turn over)

TABLE 13

CURRENT-CARRYING CAPACITIES

CABLE TYPE:	**THREE-CORE AND FOUR-CORE** Cable with or without earth core, armoured or unarmoured, including neutral screened cables
INSULATION TYPE	**THERMOPLASTIC**
MAXIMUN CONDUCTOR TEMPERATURE	**75^{0}C**
REFERENCE AMBIENT TEMPERATURE	**30^{0}c IN AIR, 15^{0}C IN GROUND**

1	2	3	4	5	6	7	8	9	10	11	12	13
Conductor size	**Current carrying capacity A**											
	Unenclosed									**Enclosed**		
	Spaced			**Touching**			**Exposed to sun**			**Wiring enclosure in air**		
	Cu		**Al**	**Cu**		**Al**	**Cu**		**Al**	**Cu**		**Al**
mm^2	**Solid/stranded**	**Flexible**		**Solid/stranded**	**Flexible**		**Solid/stranded**	**Flexible**		**Solid/stranded**	**Flexible**	
1	15	15	-	14	15	-	10	11	-	13	13	-
1.5	18	19	-	17	18	-	14	14	-	16	16	-
2.5	26	25	-	25	24	-	19	18	-	23	22	-
4	35	34	-	33	32	-	26	25	-	29	27	-
6	46	43	-	42	41	-	33	32	-	38	36	-
10	62	62	-	58	58	-	44	43	-	50	49	-
16	82	81	64	78	76	60	58	57	46	66	65	51
25	111	107	86	104	101	81	76	74	59	87	83	67
35	137	133	106	128	125	99	93	91	73	107	105	83
50	166	169	129	156	157	121	113	114	88	128	128	99
70	211	211	163	196	197	153	140	140	109	162	162	127
95	260	253	202	243	236	188	171	165	132	202	196	156
120	302	299	235	282	278	219	196	193	153	230	227	179
150	345	343	268	321	319	250	221	219	172	260	261	202
185	397	390	310	369	363	288	251	245	196	300	293	235
240	470	464	368	437	431	343	292	286	228	360	352	283
300	538	529	424	499	490	393	328	321	259	-	-	-
400	620	626	495	575	579	458	372	372	296	-	-	-
500	702	715	568	651	661	526	414	416	335	-	-	-

Table 27(1)

VARIANCE: **AIR AND CONCRETE SLAB AMBIENT TEMPERATURES**

INSTALLATION CONDITIONS **CABLES IN AIR OR HEATED CONCRETE SLAB**

1	2	3	4	5	6	7	8	9	10	11
Conductor temperature	**Rating Factor**									
	Air and concrete slab ambient temperature									
^{0}C	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
150	1.07	1.05	1.03	1.00	0.98	0.96	0.94	0.91	0.89	0.87
110	1.08	1.06	1.03	1.00	0.97	0.93	0.90	0.87	0.83	0.79
90	1.15	1.09	1.05	1.00	0.95	0.91	0.85	0.80	0.74	0.66
80	1.17	1.12	1.06	1.00	0.95	0.89	0.82	0.75	0.68	0.59
75	1.18	1.12	1.06	1.00	0.94	0.88	0.80	0.72	0.63	0.53

Table 27(2)

VARIANCE: **SOIL AMBIENT TEMPERATURES**

INSTALLATION CONDITIONS **CABLES BURIED DIRECT IN GROUND OR IN UNDERGROUND WIRING ENCLOSURES**

1	2	3	4	5	6	7	8
Conductor temperature	**Rating Factor**						
	Soil ambient temperature						
^{0}C	**10**	**15**	**20**	**25**	**30**	**35**	**40**
110	1.02	1.00	0.97	0.94	0.92	0.89	0.86
90	1.04	1.00	0.96	0.93	0.91	0.87	0.83
80	1.04	1.00	0.95	0.92	0.88	0.83	0.78
75	1.04	1.00	0.95	0.91	0.86	0.81	0.75

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Section 7

Question 30 **6 marks**

Draw and label a circuit diagram of a **three-phase** RCD used for personal protection that protects a 5-pin socket outlet in a workshop.

Question 31 **2 marks**

A RCCB protects a 230V final subcircuit and a Class I, fixed-wired electrical appliance. The RCCB has operated (tripped).

State what has occurred that has caused the RCCB to operate (trip).

Question 32 **2 marks**

State the full names for the following terms:

RCBO

SRCD

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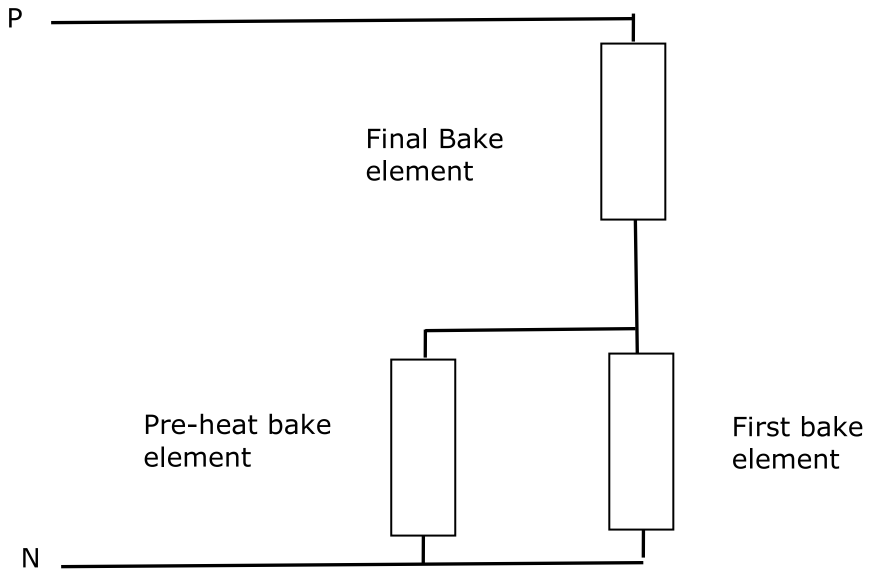
Section 8

Introduction

This is a diagram of a 230V bakery oven with three elements.



•	Final Bake element	rated at 12 kW when operating at 230V.
•	First Bake element	rated at 8 kW when operating at 230V.
•	Pre-bake element	rated at 4 kW when operating at 230V

Use the information in the introduction to this question to answer questions 33, 34 and 35.

Question 33 **6 marks**

Calculate the total resistance of the oven elements.

Question 34 **2 marks**

Calculate the total current drawn by the oven when all elements are operating.

Question 35 **2 marks**

Calculate the total power dissipated by the oven when all elements are operating.

(turn over)

Section 9

Question 36 **3 marks**

A MEN, low voltage electrical installation operates at standard low voltage.

(a) What type of switchboard must be electrically closest to the point of supply?

___

(b) To which parts of the electrical installation are the ends of the main earth electrode connected?

___

(c) What is required to be attached at one end of the main earthing conductor?

___

Question 37 **3 marks**

State **six** components of an MEN system that are found in a **MEN switchboard** in a low voltage electrical installation.

1. ___
2. ___
3. ___
4. ___
5. ___
6. ___

Question 38 **2 marks**

One function of the main earthing conductor and the earth electrode in a low voltage MEN electrical installation is to connect protective earthing conductors and equipotential bonding conductors to the mass of earth.

State **one other** function of the main earthing conductor and earth electrode.

Question 39 **2 marks**

State the **two** points in an MEN system that are earthed.

1. ____
2. ____

For Candidate's Use

In the box, write the number of **EXTRA** sheets you have used. Write **NIL** if you have not used any.

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Markers Use Only			
Section 1			
Question 1	2 marks		
Question 2	2 marks		
Question 3	2 marks		
Question 4	2 marks		
Question 5	2 marks		
Question 6	2 marks		
Question 7	2 marks		
Question 8	2 marks		
Question 9	2 marks		
Question 10	2 marks		
TOTAL	**20 marks**		
Section 2			
Question 11	2 marks		
Question 12	3 marks		
Question 13	5 marks		
TOTAL	**10 marks**		
Section 3			
Question 14	1 marks		
Question 15	2 marks		
Question 16	2 marks		
Question 17	5 marks		
TOTAL	**10 marks**		
Section 4			
Question 18	4 marks		
Question 19	2 marks		
Question 20	2 marks		
Question 21	2 marks		
TOTAL	**10 marks**		

Markers Use Only			
Section 5			
Question 22	4 marks		
Question 23	2 marks		
Question 24	2 marks		
Question 25	2 marks		
TOTAL	**10 marks**		
Section 6			
Question 26	4 marks		
Question 27	2 marks		
Question 28	1 mark		
Question 29	3 marks		
TOTAL	**10 marks**		
Section 7			
Question 30	6 marks		
Question 31	2 marks		
Question 32	2 marks		
TOTAL	**10 marks**		
Section 8			
Question 33	6 marks		
Question 34	2 marks		
Question 35	2 marks		
TOTAL	**10 marks**		
Section 9			
Question 36	3 marks		
Question 37	3 marks		
Question 38	2 marks		
Question 39	2 marks		
TOTAL	**10 marks**		
FINAL MARK	**100 marks**		

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Result: ____________	Result: ________________
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